NASA-CR-194120

Scas

1 ... 4
7P

CALIFORNIA POLYTECHNIC STATE UNIVERSITY
San Luis Obispo, California 93407

Evaluation of Single and Dual Exhaust Vectored Nozzles to Enhance Aircraft Maneuverability

Final Progress Report 03/01/89 to 03/31/90

NASA-Ames Grant Number NCC 2-586

Thomas W. Carpenter, Graduate Advisor & Professor, Mechanical Engineering

Lee R. Peron, Graduate Student, Mechanical Engineering

(NASA-CR-194120) EVALUATION OF SINGLE AND DUAL EXHAUST VECTORED NOZZLES TO ENHANCE AIRCRAFT MANEUVERABILITY Final Progress Report, 1 Mar. 1989 - 31 Mar. 1990 (California Polytechnic State Univ.) 7 p

N94-70493

Unclas

Z9/05 0182834

Complete, original to M. Cardoza for file

This project was funded under the Ames Research Post-Baccalaureate Program to provide an analytical generic study of aircraft with vectored exhaust nozzles and the resultant effects of thrust vectoring on aircraft maneuverability. The flight Mach numbers selected for the study were low subsonic, high subsonic, and supersonic with approximate Mach numbers of 0.2, 0.8, and 1.5.

The research resulted in a Master's thesis by Lee R. Peron entitled *"Thrust Vectoring for Lateral Directional Stability and Control of a Single Engine Fighter Aircraft".* A copy of this thesis has been included, Appendix A, as the final report.

The advantages of thrust vectoring control systems which included agility, post stall maneuvering and stealth were discussed. The research included a detailed analysis of the post exit vane thrust vectoring control system. It was determined that the effectiveness and efficiency of the post exit vanes were highly dependent on the engine thrust setting, nozzle pressure ratio and the surface area, position and deflection of the vanes. At high nozzle pressure ratios and high engine thrust settings with simultaneous two vane deflections, impingement on the remaining inactive vane was noted. This resulted in large losses in effectiveness of the post exit vane thrust vectoring control system.

An aerodynamics analysis was performed using the Aerodynamic Preliminary Analysis System II computer code. The Mach number range selected for this study included low subsonic, high subsonic, and supersonic Mach numbers as originally stated in the proposed research. The results of the aerodynamic study indicated a reduction in skin friction drag coefficients and a reduction in stability coefficients with a reduction of vertical tail size. However the potential drag reductions were eliminated by the drag increases encountered by the thrust vector control system hardware. The study indicated that thrust vectoring is useful at high altitudes and low speeds where the dynamic pressure is low and tail surfaces are ineffective.

A stability analysis was also performed. For observing the improved yaw characteristics the sideslip transfer function became the important parameter. In addition, it was suggested that an optimum combination of thrust vectoring with vane deflection scheduling, tail size and rudder control power exists.

The objectives of this research to provide a generic study of aircraft with thrust vectored exhaust nozzles were met and exceeded and culminated in the successful completion of the Master's of Science Degree in Mechanical Engineering by Lee R. Peron.

THRUST VECTORING FOR LATERAL-DIRECTIONAL STABILITY AND CONTROL OF A SINGLE ENGINE FIGHTER AIRCRAFT WITH VARIOUS TAIL SIZES

A Thesis
Presented to the Faculty of
California Polytechnic State University
San Luis Obispo

In Partial Fulfillment
of the Requirements for the Degree of
Master of Science in Engineering

by
Lee R. Peron
June 1990

ABSTRACT

THRUST VECTORING FOR LATERAL-DIRECTIONAL STABILITY AND CONTROL OF A SINGLE ENGINE FIGHTER AIRCRAFT WITH VARIOUS TAIL SIZES

Lee Ronald Peron

June 1990

The objective of this investigation is to determine the advantages and disadvantages of using thrust vectoring for lateral-directional control and the effects of the reduction of tail size for a single engine aircraft. The aerodynamic characteristics of the F-16 were generated by using the Aerodynamic Preliminary Analysis System II (APAS) panel code. The resulting lateral-directional linear perturbation analysis of a modified F-16 with various tail sizes and yaw vectoring was performed at several different speeds and altitudes to determine the stability and control trends for the aircraft compared to that of a baseline aircraft. A study of the "paddle" type turning vane Thrust Vectoring Control System as used on the NASA F/A-18 High Alpha Research Vehicle is also presented.

TABLE OF CONTENTS

Chapter		Page
	List of Symbols	vii
	List of Figures	xiv
1.	Introduction	1
2.	Advantages of Thrust Vectoring Control Systems	6
3.	The Thrust Vectoring Control System	14
4.	Aerodynamics	22
5.	Stability Analysis	34
6.	Conclusions and Recommendations	46
	List of References	48
	Appendix A: List of Equations	52
	Appendix B: Programs	57
	Figures	75

PRECEDING PAGE BLANK NOT FILMED

CHAPTER 6

Conclusions and Recommendations

Conclusions

At high altitudes, low speeds and high engine thrust settings, thrust vectoring control can significantly increase the aircrafts capabilities in maneuverability and spin control.

The effectiveness and efficiency of post exit vane thrust vectoring control systems are highly dependent on the engine thrust setting, the nozzle pressure ratio and the area, placement and deflection of the vanes.

The drag and weight reductions due to the decrease in vertical tail size are not large enough to compensate for the increases due to the current post exit vane thrust vectoring systems, but future systems will have improved efficiency, effectiveness, drag and weight effects and will increase the aircraft's performance.

Large disproportional changes in the magnitude and phase characteristics of the frequency response for the sideslip, heading and bank angle transfer functions occur with the introduction of thrust vectoring and the reduction of vertical tail height.

The vertical tail height can be reduced significantly for an aircraft by using thrust vectoring, however, only through careful attention to the tail size, vectoring effectiveness and vane/rudder scheduling will the optimum control and performance be obtained.

Recommendations for Future Research

For future research it is recommended that the effects of a more advanced axisymmetric pitch/yaw thrust vectoring nozzle design be investigated.

To increase two vane effectiveness and efficiency it is recommended that all post exit vanes have coordinated symmetric and asymmetric deflections to eliminate jet impingement interference and to allow inactive vanes to act as aerodynamic control surfaces.

It is necessary to investigate the effects of a feedback control system to determine the amount of vertical tail height reduction allowable to maintain level 1 flying qualities.

Further studies on the effects of pitch/yaw thrust vectoring control power during non-steady state flight conditions and non-linear regimes such as high angle of attack flight, takeoffs, landings and maneuvering flight should be performed.